DOCUMENT RESUME

ED 263 086 SP 026 759

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TITLE	Partners in Curricular Reform: Computers and Creativity.
PUB DATE	Jul 85
NOTE	13p.; Paper presented at the World Assembly of the International Council on Education for Teaching (32nd, Vancouver, British Columbia, Canada, July 22-26, 1985).
PUB TYPE	Speeches/Conference Papers (150) -- Reports - Descriptive (141)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Cognitive Processes; *Computer Assisted Instruction; *Creative Development; Discovery Processes; Elementary Secondary Education; Learning Strategies; *Microcomputers

ABSTRACT

In Southern Wisconsin and Northern Illinois a group of schools has united together to form the Beloit Educational Computing Consortium (BECC). A recent survey of selected teachers in BECC schools indicated that even though the schools do not consciously set out to teach creativity via computers, substantial creative behavior is demonstrated by the children who use the computers. According to the teachers, creativity has manifested itself the most clearly when pupils program and when they write using the word processing capabilities of the computer. By applying these tools, pupils develop their own ideas after trying different options. The surveyed teachers also noted the ways in which potential creativity can be blocked. In particular they noted that the least stimulating examples of software contain lengthy directions, few choices, and minimal interaction and reinforcement. In this paper, an analysis of the human thinking processes which lead to creativity forms the foundation for a discussion on the salient factors that should be incorporated into a computer curriculum designed to enhance and develop creative thinking in students using the computer as a tool. (JD)

ED263086

Partners in Curricular Reform: Computers and Creativity

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A Paper Presented at the Thirty-second ICET World Assembly

Vancouver, July 22-26, 1985.

I. Introduction

A. Preliminary Survey. In southern Wisconsin and Northern Illinois we have a group of schools united together to form the Beloit Educational Computing Consortium (BECC). A recent survey of selected teachers in BECC schools indicated that even though the schools do not consciously set out to teach creativity via computers, substantial creative behavior is demonstrated by the children who use the computers. According to the teachers, creativity has manifested itself the most clearly when pupils program and when they write using the word processing capabilities of the computer. By applying these tools, pupils develop their own ideas, and they do so after trying different options. They infer and plan. They "teach the computer" and they interact with it. When pupils develop their own programs, when they compose several drafts of a composition, when they experiment with different ways of playing games, then they see what happens *if* ...then they are being creative, according to their teachers.

The same Beloit teachers who reported creative behavior in their pupils who use computers also noted ways in which the potential creativity is squelched. It is interesting to note that "mechanical obstacles" seemed to block creativity more than negative attitudes or lacking abilities.

For example, limitations in learning the keyboard, typing, spelling, punctuation, and understanding directions were repeatedly listed as factors that interfere with full utilization of the computer. Also, the teachers mentioned difficulties with getting and keeping the computer running. Furthermore, they recognized the limitations of certain software. The least stimulating examples contain lengthy directions, few choices, and minimal interaction and reinforcement.

These obstacles can be overcome in a computer setting. They are not major blockages to attaining increased creative behavior.

So if creative behavior can appear regularly without consciously setting out to elicit it, and if the reported obstacles are relatively easy to overcome, an explicit curriculum may result in even more creativity as pupils use computers. I am here to share some background issues that are being considered as we explore this matter in Beloit.

B. Conscious Processes. First a word about conscious thinking processes. Sherry Turkle in her book *Computers and the Human Spirit* says "...physicians claim that a lot of what they do [in diagnosis] is intuitive. It is reasoning through the associations built up over years of practice. (1984, p. 245) [However,] A different set of assumptions guide artificial intelligence investigators when they study medical diagnosis. Their goal is to capture the process as a set of explicit procedures that can be written as a program. After extensive interviews with physicians, they try to pin down every aspect of how these people make decisions. What once seemed intuitive to the physician has been shown to be formalizable," claims Turkle.

She goes on to say that "...the interaction of a small number of quite simple processes can create an impression of ungraspable complexity [but]...the appearance of complexity does not rule out causal simplicity.

The study of creativity in education, in science, and in the arts encounters similar reactions. "Creativity is too complicated and magical to analyze or try to consciously influence. We can't and we shouldn't tamper with it," say many people."

Of course we educators and others do analyze creativity into component parts. Those who strive to increase creativity in themselves and others stress that awareness of creativity's key features ultimately can lead to changed attitudes, enhanced abilities and useful strategies.

C. Creative Processes Creativity is a process of freedom operating within structure aimed at a problem or opportunity for expression. The freedom is often in dynamic tension with the structure such that the structure may change or be seen in a new light as the process of creativity proceeds. Creativity is not necessarily exotic or dramatic. Most people experience it, sometimes without thinking of it as creativity. Often it happens like this:

> You discover that an incomplete idea attracts your attention. You cannot give it up, and while you do not want to give it up, you do want to make progress in solving it or in giving it a satisfactory expression. As you search for a solution, you attempt various strategies and consult authorities. The authorities include books, teachers, friends, parents, or siblings, as well as formulas, and reminiscences of past experiences of your own. As you play with your ideas, they do not get prematurely criticized. The possible solutions tantalize you. You want each of them to be THE answer, but you tolerate the ambiguity that accompanies the elusive breakthrough. Moreover, you seek the resources without the search being either required or anxiety producing. You simultaneouly play with potential solutions as well as imitate the best in the sources. Finally, a solution comes. You know that you have arrived at a new level of understanding and perhaps others recognize it as well. You have a vested interest in your emerging learning. This type of experience can happen in school, but it is just as likely to happen elsewhere. It doesn't happen often enough, of course. It is learning of the finest kind (Warren, 1983).

What is described above comes close to matching "the creative process" as inferred from comments by recognized creative persons in various fields (Ghiselin, 1952). They testify to realizing a time when an amorphous problem is finally better understood. This represents a breakthrough, but not one that completes the process. When the problem is understood, divergent ideas emerge without the squelching that victimizes ideas which die before growing and developing. When a large number of potential solutions emerge simultaneously, subconsciously as well as consciously, raw material exists for helping creators jump to a solution. For example, a well understood dilemma generates a number of hypotheses and one or a combination of several may ultimately provide the needed result.

II. Conscious Creative Thinking Strategies and Computers

Jerome Bruner states that "....the development of human intellectual functioning from infancy to such perfection as it may reach is shaped by a series of technological advances in the use of mind. Growth depends upon the mastery of techniques and cannot be understood without reference to such mastery. These techniques are not, in the main, inventions of the individuals who are 'growing up'; they are rather skills transmitted with varying efficiency and success by the culture" (Bruner, 1964).

Bruner further suggests that the principal evolutionary change in human beings has been alloplastic rather than autoplastic. That is, people have linked up with new external implementation rather than by any change in morphology. Guilford (1962) and others also attest to the learned nature of creative skills and the likely extension of anyone's creativity which comes from linking up with creative thinking strategies.

Creative thinking strategies are external aids that may not necessarily be a conscious part of a creator's thinking processes, but upon reflection turn out to be important contributors. They go by various names that are not necessarily standardized. Examples include brainstorming, synectics, morphological synthesis, and free association. Taken as a whole they offer a sample of techniques that facilitate creativity. In Beloit, we want to develop a curriculum in which these techniques are part of computer education.

A. Brainstorming. First, "brainstorming." Although the term has been in common use by business and corporations since the early fifties and by the population at large for the last ten or fifteen years, its technical definition was developed by Alex Osborn in the late 1930's. Brainstorming is a technique especially suited for problem solving. Brainstorming sessions have long- and short-term goals. The long-term goal is the solution of a problem. In the short run the goal is the production of a large number of ideas which may have potential value as solution. Osborn (1963) lists four basic underlying assumptions of brainstorming:

1. CRITICISM IS RULED OUT DURING A BRAINSTORMING SESSION. Any adverse judgment of ideas must be withheld until a later time.
2. 'FREE WHEELING' IS WELCOMED DURING THE SESSION. The wilder the idea, the better; it is easier to tame down than to think up.
3. QUANTITY IS WANTED. The greater the number of ideas, the more the likelihood of useful ideas.
4. COMBINATION AND IMPROVEMENT ARE SOUGHT. In addition to

contributing ideas of their own, participants suggest how ideas of others can be turned into even better ideas, or how two or more ideas can be joined into still another idea (p. 156).

Similar assumptions can be inferred from what happens when one programs a computer. While criticism is not absent from the process of programming, the common procedure of "debugging" suggests a change in order to improve rather than a squelching red light that says "Stop! You are wrong!" Debugging allows ideas to emerge in a context of positive suspension of judgment. Consequently, experimentation and daring emerge as a welcome part of programming. The immediate feedback provided by the machine gives the programmer a message that is helpful, indeed: "Either the program runs or it doesn't!" If it runs, the daring has paid off, and the wild idea has been reinforced.

Furthermore, procedural languages encourage borrowing just as brainstorming enourages borrowing. A procedure may be legitimately lifted from one program for use in another. It may be taken in part and modified to suit a new setting. Structured computer languages lend themselves to variations, permutations, and combinations. Borrowing is legitimate in such settings, just as in brainstorming. Isn't it unfortunate that we parents and teachers, in our zeal to help our children to think more divergently, have sometimes unwittingly taught them to avoid imitation. "Make something new," we tell them. "[And] it must be your own."

Computer users of all ages typically see the advantages of building onto someone else's programs or procedures. Maybe the ease with which these electronic books (Read: programs or procedures) can be taken off of their "shelves" without moving the original has something to do with the psychology of it.

Brainstorming's emphasis on quantity also has a parallel. Teachers testify to the substantial output generated by many of their pupils who use computers.

B. Synectics: Personal Analogy. Several creative thinking strategies may be classified under the heading of synectics. The word is derived from the Greek synecticos which means "the joining together of different and apparently irrelevant elements" (Gordon, 1961, p. 3). Conscious use of metaphor is a key to the synectics process. Aristotle (Poetics, in Butcher, 1951, translation) noted that artists recognize the value of "giving a thing a name that belongs to something else." William Gordon stresses the importance of "making the familiar strange" as part of the synectics process. In his book The Metaphorical Way of Learning and Knowing (1969) Gordon states, "...the most important element in the creative process is 'Making the Familiar Strange,' because scientific breakthroughs as well as visual and literary innovations depend on strange new contexts by which to view a familiar world" (p. 3).

Gordon goes on to describe several operational mechanisms for making the familiar strange. Each is metaphorical in character. All provide a non-rational, playful, stimulating atmosphere. One, called personal analogy, begs the comparison with the programming language, Logo. Personal analogy is a description of how it feels to be a particular object or living thing. It involves empathizing with things outside of oneself, the more completely, the better. Gordon (1969) notes some scientific discoveries that seem to suggest the use of this technique.

> For example,"...the great Dutch chemist Kekule...in attempting to solve the riddle of the molecular construction of benzene...imagined himself to be a snake swallowing his tail. This personal analogy led to the concept of the molecules being set in a circular pattern" (p. 23).
>
> T. A. Rich, a scientist with over 100 patents involving electricity and electronics, "...puts himself in the middle of a problem, trying as he says to 'think' like an electron whose course is being plotted or imagines himself (to be) a light beam whose reflection is being measured" (p. 23).

Children can learn effectively using the technique of personal analogy according to Gordon. Empathy provides a way of learning that is highly individualized and non-threatening. It allows explorations and development within a set of ground rules that says, in effect, "Start on your own terms. Your perspective is a meaningful one that can lead to wider and deeper knowledge."

Similar refrains emerge from the literature regarding Logo. If we think of creators and computer programmers as builders, both need tools with which to build. Creative thinking strategies are tools; so is the turtle, a computational "object-to-think-with," according to Seymour Papert (Papert, 1980). Early turtles were mainly computer controlled cybernetic animals with a pen that could be raised and lowered to trace outlines on paper. Most turtles enountered in Logo environments today are small, movable, triangular shapes on the monitor of a computer.

By using experiences in moving their own bodies, a child can "teach" the turtle to move across the screen leaving a trail. The command FORWARD 100 makes the turtle move in a straight line a distance of 100 turtle steps. Typing RIGHT 90 causes a pivot of 90 degrees since the turn affects the turtles heading. PEN DOWN causes a visible trace; PEN UP leaves no trace. Programming is thereby introduced by the metaphor of teaching the turtle. For example, the procedures SQUARE and TRIANGLE can be simply constucted out of the appropriate combinations of FORWARD, RIGHT, and/or LEFT. From building blocks such as SQUARE and TRIANGLE, more complex combinations can emerge such as graphic representations of houses, checkerboards, and other designs. In other words, new procedures once defined can be used to define others and these others can be use to define still others and so on. The manipulations are often enjoyable for children of all ages, but "...very powerful kinds of learning are also taking place," says Papert. Children working with an electronic sketch pad are learning a language or talking about shapes and fluxes of shapes, about velocities and rates of changes, about processes and procedures.

Logo graphics users identify with the turtle. In effect they say to themselves, " I go forward 50 steps and then I turn right 90 degrees. I go forward another 50 steps and then repeat the process." The learner becomes the turtle and senses the twists, turns, repetitions, and delightfully dizzying recursions that can form the basis of programming and visual art.

The turtle, like other creative thinking devices, serves as a catalyst for developing ideas. It is especially similar to the synectics strategy of personal analogy in that the users physically identify with something outside of themselves.

C. Morphological Synthesis. While personal analogy represents the playfulness end of a continuum, morphological synthesis connotes organization and comprehensiveness. Davis (1971) defines morphological synthesis as follows:

> First identify two or more dimensions (or attributes) of the problem...Second, list ideas for each of these dimensions...Finally, evaluate the huge number of all possible idea combinations (author's italics).

From the tremendous number of ideas produced by such combinations, most will be useless. However, a few may be quite promising themselves or may inspire a related idea. J. E. Arnold (1962) says,

> "The morphological analysis is the most comprehensive way that I know of to list and examine all the possible combinations that might be useful in solving some given problem (p. 257)."

Shallcross (1981) describes how Fran Stryker, creator of the Lone Ranger, used this process to develop a virtually endless supply of story plots. Stryker generated ideas under four headings which were written on a chart on his wall: character, goal, obstacle (to the goal being accomplished), and outcome. With as few as ten ideas under each heading, 10,000 variations were possible when the ideas were combined with each other. Shallcross notes that the morphological synthesis instrument is "...a powerful one in demonstrating creative behavior. Although the structure for creating story plots is provided, the content comes from the creator. Morphological synthesis is a beautiful springboard and a perfect partner for people who feel incapable of producing anything original" (p. 152).

Davis notes that, "at the very least, we must agree that (a) such procedures can lead to new, potentially valuable ideas and problem solutions, and (b) even the most intuitive of creative persons may find themselves modifying attributes and forcing combinations..."

Of course computers can easily list the attributes of dimensions and direct the printing of every conceivable permutation and combination. This is one similarity that computers have with morphological synthesis. The ease and speed of such listings is helpful in many tasks. However, a more basic and educationally significant link between morphological synthesis and computers exists as well. Its practical usage requires planning and separating out the relevant from the irrelevant features. Building blocks of procedures can combine to form larger units. Variations in the smaller or larger parts, when combined in a program provide a pool of many ideas, some of which may be useless, others uninspiring, and a few fascinatingly appropriate.

The developers of Logo made it a language that is "user friendly." This means that commands and other features of the language relate simply and directly to what learners already know in their non-computing lives. However, friendliness to a teacher must also mean leading pupils to new vistas and strengths as well. Logo attempts to do this in one way by emphasizing "top down" programming. To program from the top is to plan. It is knowing where you want to go in advance, and anticipating the parts that will make up your intended whole. Like the results of morphological synthesis, the details of the whole are not known from the beginning, but a structure is formed which maximizes the chances of exploring a large number of options. User defined procedures can be combined in a far-ranging number of combinations.

Abelson (1981) notes that this system interaction plays a crucial role in helping children become better thinkers. When people explore using Logo, they are continually defining new procedures and modifying old ones. (isn't this the way a composer, an inventer, a mathematician or a teacher works? Isn't this the way all creators work?)

Abelson notes a higher level of synthesis in Logo as well. He says,

> The best kind of Logo activity is a synthesis of programming, mathematics, aesthetics, and above all, the opportunity to explore." (p. 106)

<u>D. Free Association Strategy</u> In its simplest manifestation, the free association technique involves repeatedly presenting the same "stimulus" to a person, with instructions to give a different response each time. The underlying assumption is that that the response which occurs is the one which is dominant in the response hierarchy at that time. It is the most common response; it has the greatest strength at the moment of stimulus presentation. Responses that are uncommon (cf., original) must be lower in the reponse hierarchy. The objective is to tap into them. They may provide some raw material for the creative challenge at hand and force the thinker to make new links between elements of a situation.

Maltzman <u>et. al.</u> (1958, 1960) found that requiring subjects to give different verbal associates each time a particular list was presented transferred to test situations. Davis, Manske, and Train (1967) noted that "...practice in free associating...MAY very well result in a tendency to give more original verbal responses in open-ended transfer tasks such as the Unusual Uses test.

Word processing via computers offers opportunities to, in effect, apply the basic premise of the free association technique. That is, there is more raw material below the surface in the "preconscious" of a thinker than that which immediately manifests itself in response to a creative challenge. Access to this pool can be increased. Computerized word processing facilitates learning through its forgiving nature. Mistakes can be effortlessly corrected at the appropriate time. Numerous drafts can each concentrate on certain key features of a statement while keeping the rest intact and already proofread. An emerging written work can be repeatedly encountered with different goals in mind each time. For example, active voice, punctuation, correct spelling, structural organization and word choice can be explored on different occasions or left alone.

The upshot of this combination of precise storage and easy revision leads to more adventurous writing and thinking. Ideas can be tried with impunity if they can be simply and neatly replaced or modified. Few creators are satisfied with their first drafts. Few first drafts are best drafts.

III. Computers and Creativity in Schools

A. Caveats and Criticisms. I don't want to suggest that since there may be reasons to link conscious creative thinking strategies with computers that computers should be seen as a panacea for the educational problems of the day. Wholesale takeover of schools by computers will ultimately be as unacceptable and unworkable as the singular dominance of lectures, class meetings, corporal punishment, teaching machines, new math, or creative thinking strategies. In fact a backlash could occur which would deprive schools of self-enhancing uses of computers.

Joseph Weizenbaum is an especially sensitive critic of computers in education. Weizenbaum believes that we have already been taken over by them. He thinks that they inappropriately govern both our day to day living and our frames of reference. "When, in order to understand what goes on in a faraway place, one consults statistics about that place and refuses to read novels about that place, because statistics are hard and scientific, and novels are admittedly fiction, that's bad...there are wonderful things one can do with a computer . But I wouldn't want [it to preclude other important things]," he says (1983, p). Weizenbaum emphasizes that it is easy for computers to be thought of as a quick technological fix for the educational ills of the day. The history of education teaches us the futility of quick fixes or panaceas.

Weizenbaum's points and those of other critics must be taken seriously. Maybe Sloan's anthology, The Computer in Education: A Critical Perspective (1984) should be required reading for all educators who deal with computers. Certainly, we must not be lulled into an unquestioning acceptance and blind enthusiasm for computers. Neither should we overlook the role that computers can play relative to creativity.

B. Conclusions. Papert (1980) is not unaware of the dangers that can come from the takeover of schools by computers or insensitive computer use, but he thinks the advantages of their application outweighs their threat. Moreover, he stresses that computers provide a new catalyst to basic challenges in learning. Learning should happen like this according to Papert. "First relate what is new and to something you already know. Second, take what is new and make it your own. Make something with it, play with it, build with it" (p.).

Such constant tension between what people already know how to do and what people are capable of learning provides a moving force for intellectual development. It is Papert's belief that the learning of any organized scholarly discipline consists of bringing its recognized accumulated knowledge into contact with the very diverse personal knowledge of the learner. To do this educators should allow the learner to construct and work with personal concepts that the scholars may traditionally refuse to recognize as part of their area of concern.

The similarities between this perspective and descriptions of creative breakthroughs are striking. In both cases bridges must be built between what the potential creator/learner knows and what the challenge offers. Ideas must be nurtured, not squelched. Then the probability of creative responses will be increased.

Computers can be useful, effective tools...devices to be applied as important means to important ends. Computers may even deserve a special place as helpmates to more basic goals. Abelson believes that "Computational description...provide[s] a perspective, a collection of 'tools of thought.'" (p. 112). Papert notes that "...a salient feature of human intelligence is the ability to operate with many ways of knowing, often in parallel, so that something can be understood on many levels...the fact that I ask myself to 'think like a computer' does not close off [other ways of thinking]."

Similarly, creative thinking strategies have seldom been endorsed as the singularly sufficient ingredients for eliciting creative behavior. More is involved. Creative thinking strategies provide a spark in some cases; they help. They cannot stand alone, however. Their form must be a secondary partner to the substance, the things and ideas that are being created.

Two ostensibly competing goals characterize many attempts at educational reform. One aims at maximizing freedom for individual development. This perspective asks, how can learners be "turned loose" to experience the power of their individuality? How can schools best allow them to play with ideas, to experiment, to be adventurous, to become self-motivated learners and problem solvers, and to chart new directions?

The other point of view strives for thoroughness, discipline and organization. It asks, how can pupils best learn from others? How can they take on the words and ways of more experienced forerunners? How can they become a part of systems that function effectively?

Ineffective learning is characterized by tentative freedom and stilted organization. Neither the liveliness of unrestrained, natural energy nor the efficient beauty of highly integrated structure are present. Sometimes in the search for better methods, either playfulness or organization is embraced alone to the exclusion or diminution of the other. In fact, neither can endure without the other.

Computers offer assistance to this challenge. When used as "devices-to-think-with" they can draw out both playful and organizational strengths of learners. They can complement instruction in mathematics, language, literature, and science. They can challenge their users to be daring thinkers. If sensitively introduced into schools, they can be tools of the first order that show pupils their own inherent possibilities. They can help people become more creative

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